Scarcity theory and maritime clusters: from paradox to modelling

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Clusters of industry are widely accepted as important aspects of the regional economies wherein they are disposed, since within them, complementarities of the cluster members are witnessed to provide synergies and positive externalities. These forces deliver the cornerstone of collective sustainability, that is exhibited within healthy industrial clusters. One type of clusters that is deemed of distinct reputation, is the sort that is formulated around a core of maritime activity. Maritime clusters are discrete and volatile cases of the concept, since the maritime sector bears exemplary effect on any given economic cycle and simultaneously, markets riddled with shipping activities portray near-perfect competition. Maritime clusters have provided research and practice with a fertile ground to formulate and assess theories, though we are far from a unifying one. In addition, the literature is not without paradox. One paradoxical instance that affects all clusters, is that of the scarcity principle's applicability within the rudiments of a cluster, as it pertains to a domain that hasn't been researched extensively. This work relinquishes a baseline model that deconstructs the scarcity paradox within maritime clusters, that will hopefully provide a feasible stepping stone for further theoretical and empirical research, with distinct implications for management, governance, and policy.

Keywords: strategic management; industrial cluster; scarcity principle; scarcity paradox; innovation modelling; cluster modelling.

1 Introduction

Clusters of industry comprise an agglomeration of relational firms, agencies, and institutions, that support a central activity and/or industry, in a specific locality. Within this general interpretation, the distinction of firms and institutions is present, to portray the characteristic of operational diversity within an industry cluster. Many clusters exhibit semblance to centralized constructs, as the sum of their operations revolves around a unifying activity. The core can bear the role of the cluster instigator as well and can be assigned not only to an economic entity, but to a tertiary education institution, a research centre, or, recently, a cluster organization. Each type of member within a cluster has its own role in solidifying and

sustaining the health of the collection of entities. In addition, the outcome of cluster health will contain not only each member's contribution to the cluster, but all the members' relations with each other. The three pivotal roles within a cluster are used in the representation provided above, to symbolize the most basic of cluster characteristics, that of relational proximity.

Firms compete and cooperate with one another to innovate and create the marvel of dynamics exhibited within a cluster. Knowledge creation institutions are active within a cluster to provide the necessary kindling for the system of innovation to start its volatile expansion. Simultaneously, agencies (governmental, international, or even private bodies) are necessary to provide the cluster with discrete governance and policy. The qualifier 'discrete' is used, since policy alone can only assist and facilitate operations, not dictate them. If anything, when a cluster is formulated, it has a will of its own, that not one member within it, no matter how important, can twist it towards its own accord. The types of cluster members presented above, are merely indicative; knowledge creation can originate from firms and policy can remain a latent quality. In addition, cluster members can evolve and interchange roles and operations within a cluster, since nothing within a cluster of industry remains static.

Clusters expand their function within a region to such an extent, that they may overshadow any other operation; to the point that the region itself is characterised by the cluster's principal industry. Examples such as Hollywood and Silicon Valley are particularly familiar. This would seem as a predominant characteristic of cluster manifestation: the locality wherein its activity resides, is painted with the colour of operations within the cluster. These operations include the centralised effect referenced in the classification provided, as clusters seem to include a centralised activity, where all the cluster branches stem from. The final analytical aspect that should be referenced per the provided cluster description, is the relational characteristic. Each cluster member forms proximate and diverse relations with

other members, to provide an interconnected system very similar in function to a super-system such as an ant colony, a bee hive, or a living organism. Within a diverse array of subsystems, the cluster member performs its own respective function, but also cooperates with its environment, to fulfil the existential purpose of the system. Therefore, all members of the cluster have their own duty to perform, towards the cluster's strong constitution. Simultaneously to their function, they hold their respective stake, that most always involves the well-being of the other cluster members, as well. With this rationale, the necessary culture of mutualism within a cluster of industry derives even from the simplest notions, based upon a generic representation, such as the one presented at the beginning of this section.

The problem with clusters arises, as with many circumstantial topics that may gather bulk attention, with what they encompass; and that is the promise of prosperity, given that the cluster culture is respected. Understandably, in recent years, public policy in many regions has focused in cluster manifestation, providing a range of effectiveness within its results (Yin et al. 2018). Research has shown varied outcomes as to the concept that cluster manifestation is better left to systemic, or natural circumstances, away from policy and decision-making. But this would not mean that the drive to investigate the phenomenon should be left to halt, but rather that, if clusters are understood in more depth, then maybe their threads can be recreated. For this reason, towards the investigation of clusters' governing dynamics, any review of the respective body of knowledge will uncover, that, in many cases, the theory is riddled with paradox. If not paradox, then contrast and at the very least, obscurity.

To tackle this issue, at first a theoretical investigation of the paradoxical instances of the theory would require assessment. The outcome of this process would then facilitate the formulation of frameworks and models that may serve as a stepping stone towards greater insight regarding the rudiments of industrial clusters. Such an attempt is relinquished within this work. A conceptual analysis with respect to the obscure characteristics of the theory is

provided, to subsequently render a model that explains an elementary paradox within industrial cluster dynamics; one that concerns scarcity, as the latter is at the forefront of attention with reference to any manifestation regarding populous proximity. The process of modelling scarcity to deconstruct paradox is rooted in acknowledging maritime clusters as the instigators of the conceptual definition with respect to the scarcity paradox that is exhibited in all clusters. The model formulated herein aspires to contribute towards a better understanding of the dynamics that are encapsulated within clusters of industry.

2 Industry clusters and maritime paradox

The theory of industrial clusters includes many extracts that could be regarded as ranging from mysterious, to paradoxical. Even from its conception, the theory manifests signs of paradox. Alfred Marshall's (1920) 'economies of agglomeration' provide an effective framework to analyse clusters, yet in his work, Marshall mentions that the mysteries of trade within an industrial locality "…become no mysteries; but are as it were in the air and children learn many of them unconsciously." An industry's expected evolution, according to the context set by strategic management, will move from fragmentation towards consolidation (Wheelen and Hunger 2013). This, due to the simple reason that common business practice will inevitably yield a consolidated result, as mergers and acquisitions will set the foreseeable norm as an industry progresses. The aberration of clusters skews part of this evolution inversely. A cluster could be thought to begin as a consolidated formation, that will in turn strategically evolve into a fragmentated state, which will be brought up by the novel industrial activity generated through its system of innovation. That's just one more instance of clusters' paradoxical health through not only not playing by the rules, but instead thriving through the direct inversion of expected business dynamics.

Many industry cluster characteristics, such as centralization and agglomeration, competition and cooperation, globalization and localization, specialization and diversification, and creative destruction with respect to innovation (Abernathy and Clark 1985), seem to share conflicting features, as they formulate bipolar dynamics, thereby creating paradox. The latter appears to be imbedded within the theory of the former, that has even been coined as chaotic (Wang 2010). Globalization, as Porter (2000) points out in his 'location paradox,' should foster the demise of regional importance. Yet, the volatility of clusters seems to be directly correlated with globalization (Bathelt 2004; Watkins 2010); insofar that locally-sourced competitive advantage resonates on a global scale (Rədulescu et al. 2015). Another paradox set by Porter that is analysed within the literature (and relevant to scarcity as well), concerns the mutualistic coexistence of competition and cooperation that is documented within clusters (Nadvi 1999).

Cluster paradox can entail the issues of a central governance mechanism, as discrepancies arise from its tension among networks of trust (Hsu 2004). Contradiction in clusters bears many facets and many times surfaces as 'empirical paradox' (Malmberg 1998). Another relevant cluster paradox is the simultaneous existence of "over-embeddedness and under-socialization" within local industrial sectors. This is coined as the 'distanced neighbour' paradox that exposes inconsistencies of regional specialization paired with paradoxical instances of isolation (Bathelt 2005). The 'distanced neighbour' paradox may come in tandem with 'urban paradox' in industrial districts, when rural and urban populations overlap (Carmo and Da Costa 2016). The role of entrepreneurship in industrial districts may allow instances of paradox, as it is fused with occurrences of 'organized anarchy' that are witnessed in clusters (Johannisson et al. 1994). Paradox resonates with industry clusters of many sectors, yet one could assert that there is a sector which thrives on paradox and simultaneously delivers clusters of global distinction. Maritime clusters exhibit paradoxical

traits, yet at the same time they are considered as beacons of excellence for regional economies, as well as indicative benchmarks for cluster theory.

As mentioned, the maritime sector is not devoid of paradox. Instances of paradox within the literature include the international dimension of maritime heritage (Maarleveld 2012), in addition to paradox in the representation and perceptions of seafarers (Begiato Bailey 2015). The prerequisite of environmental strategies in conjunction with the accentuation of global maritime cargo flows (Svindland 2015) creates paradox, as does maritime-cargo-dependency in contrast with low infrastructure development (Setti et al. 2011). The sector homes paradox with reference to technological maritime advancements and required skilling (Bhardwaj 2013), in addition to many paradoxical instances with respect to maritime transportation safety (Størkersen et al. 2017). The 'energy paradox' within transportation systems (Balland et al. 2015) involves the maritime sector, in addition to the 'globalization paradox,' as global governance specifics intersect with maritime security operations (Aarstad 2017).

Paradox can be distinctive of maritime affairs and partake in a region-specific hue, such as the 'Arctic paradox' (Palosaari 2011). Instances of maritime-driven-growth clashing with issues such as deficits in trust and political discrepancies are prevalent (Togo and Naidu 2014), along with apparent ramifications of national maritime strategies (Rehman 2017). Paradox in the maritime sector may even extend to maritime sustainability issues (Voisin et al. 2005), risk management (Morel and Chauvin 2006), piracy (Cordonnier 2001), refugee flows (Koh 2012), and social practices (Mendoza 2015). In addition, paradox can be present in the rudiments of specific maritime clusters, through the fusion of positive externalities with perceived vulnerabilities, such as in the maritime cluster cases of Singapore (Heng 2013), Portugal (Salvador 2015), and Piraeus (Pardali et al. 2016). An indicative research question

with respect to maritime cluster paradox would involve the governing dynamics of scarcity within a cluster. Maritime clusters provide viable benchmarks for cluster conceptualization and definition (Doloreux 2017; Fløysand et al. 2012), models' (Rupo et al. 2018; Stavroulakis and Papadimitriou 2017; Zhang and Lam 2017; Zhang and Lam 2013) and frameworks' (Koliousis et al. 2018; Koliousis et al. 2017; Monteiro et al. 2013; Stavroulakis and Papadimitriou 2016) formulation, yet maritime cluster theory is barren with respect to the applicability of scarcity within the threads of a cluster. This concept is rightfully interesting, as the state of scarcity within a cluster gives rise to a novel domain of research potential, especially concerning maritime clusters; this because the latter are created upon markets of near-perfect competition, holding a definitive stake in regional growth, and giving birth to some of the most legendary and record-setting narratives in international business.

Scarcity is relevant to regional economies and especially to the maritime domain, for clustering of maritime activities produces many positive externalities that play an important role in a locality's competitive position, within the globalized economy (Laaksonen and Mäkinen 2013). Thus, the maritime industry, industrial clusters, and scarcity, are indicatively relevant, when merged conceptually. This goes not to state that scarcity may not be resonant to any (if not all) other clustering cases; just that the maritime domain bears an exemplary point of reference to study industry cluster paradox, especially with reference to scarcity. As regional maritime economies expand to give way to flagship maritime clusters, scarcity is put to a revealing practical trial. Therefore, it is not surprising that the one sector that stands as the backbone of global trade, is able to provide the conceptual kindling for the investigation of scarcity within its cluster formulations. The research query initiates by addressing scarcity within a maritime cluster, wherein paradoxically, regional resources may be capped, but populous proximity flowers amongst entities that venture for these identical resources.

3 The scarcity paradox in maritime clusters

One of the elementary economics' concepts of rational thought, is that of scarcity. The scarcity principle sets the tone for much of business policy and serves as a segue for prudence. It pertains to a critical element of modern discourse, as a conceptual instigator for the basis of rationality (Martins 2011). Scarcity can be considered for many applicable topics, including products, natural resources (Smith 1978), commodity pricing (Mueller and Gorin 1985), franchising (Alon 2006; Baena Graciá 2010; Choo et al. 2007; Flint-Hartle and de Bruin 2011), income (Tinbergen 1977), and capital (Chimeli and Braden 2009). For products especially, the scarcity principle stands to many times dictate consumer responses, to the point of achieving a competitive advantage within itself (Brock 1968). Types of scarcity, such as demand- or supply-driven scarcity, can have different effects upon the economic cycle. Studies demonstrate the varied effect of scarcity to consumer decisions, with respect to exclusivity or popularity and the exhibition of important spill-overs to functions such as marketing (Thompson et al. 2014; Van Herpen et al. 2014).

The importance of the concept seems to transcend an explicit domain, such as economics; its effects are visible in many tangible and intangible factors, such as sexual risk and HIV prevalence (Jennings et al. 2017), depression (Haggag et al. 2011), sleep patterns (Barnes et al. 2012), personal freedom (Gholipour et al. 2013), conflict (Gleditsch et al. 2006; Theisen 2008), and strategy (Díez de Castro et al. 2008). When introducing the principle, many disparities may be explained, as per the influence of many factors to behavioural and decision dynamics (Wakita et al. 2014). Different approaches are introduced, as to the considerations of a scarce resource. For example, labour can be coined to include aspects of efficiency and knowledge creation (Kirshin 2013), that are considered central industry cluster aspects, as well. The concept of scarcity may be closely linked with innovation (Swami and Khairnar 2003), a core cluster function. The pervasiveness of scarcity does affect its

evaluation, even within a social context (Ditto and Jemmott 1989), whereas with respect to efficiency, it portrays a direct correlation (Luptáčik 2010).

The theory of scarcity has been investigated in tandem with many other theories, such as, property rights theory (Hussain and Windsperger 2013), role expansion theory (Lau et al. 2014), social constructivist theory (Leavitt et al. 2017), risk-sharing theory (Sun and Lee 2016), conservation of resources theory (Allen et al. 2016), institutional theory (Hachemi Aliouche et al. 2015), agency theory (Castrogiovanni et al. 2006; Combs et al. 2004; Tracey and Jarvis 2007), equity theory (Thompson et al. 2014), and surplus theory (Martins 2011), as its predecessor (Martins 2013). It would seem as though scarcity is a catalyst, a benchmark, and a kind of Rosetta stone for exploring, interpreting, and testing theories. Though this may be true, its impact on industrial cluster theory has not been adequately investigated. This stands even from the most preliminary perspective, that of conceptual friction and model development; even though the primary conundrum with respect to an industrial cluster emerges as the clash between abundance and scarcity. Thus, the theory of industrial clusters stands in wait, with respect to the applicability of scarcity theory within, as it provides an instance where the latter is one of the fundamental ideas that are breached (or portray paradox), at least conceptually. In this work, a model is extracted, revealing that not only is the principle of scarcity not fragmented, but that within clusters, it is reinforced, as well.

Among its manifestation within a given (regional and/or national) economy, scarcity may be important because of its implications to societal and decision dynamics within and among firms. At the one hand, the principle may dictate an acceptance of the limitations inherent within a region and at the other, it may stand as the motive behind zero-sum games. At a conceptual level, the scarcity principle would merely exhibit the instinctive reality, that within a given locality, resources are not infinite. This notion would give way to the school of thought with respect to conservation; though at the same time, this would lie across from

many resource cycles exhibited in nature, wherein resources are not depleted (McDonough and Braungart 2002). Contrarily, nature shows extreme abundance within a variety of (if not all) cases, since the process of resource allocation shows periodicity. Thus, there must be present a distinction between the processes that consume and deplete resources within a region and those that have the power to regenerate and utilise a resource in a perpetual manner. Processes that pertain to industries are predominantly considered of the former kind and rationalism within a modern industrial sector is mainly dictated by the generic scarcity principle.

Within the strive of efficiency that sets today's business context and amidst crises, systemic failures, and fault lines within economies, regions venture to capitalise on resources, to remain competitive. In each geographical region, the scarcity principle will dictate that economic entities must compete, for the better utilization of the resources within. The 'pie' analogy to describe the finite capacity of an economic cycle, is pervasive. The query (and simultaneous research question that is put to rest with the model developed herein) then as to the resource dynamics within a maritime cluster, would be, at least, commonsensical. Why is there, in a world where resources for industry are at a steady course of constant depletion, that one may witness regions that can harbour an extreme concentration of sustainable industrial activity? An evident answer would be that natural resources would warrant the aggregate. But many regions that sustain maritime clusters, do not harbour any source of natural resources, that at least at first glance, can provide the sustenance required for all the entities active within the cluster. Furthermore, there are cases where a maritime cluster was provided an initial source of natural resources, where, after their depletion, the cluster not only survived, but strategically evolved (Bjarnar 2009). To make matters worse, not only may natural resources be absent, but the entities within the cluster seem to thrive, grow, and prosper, simultaneously. When direct competitors not only exist, but flourish collectively and

the cause is not an overabundance of a natural resource (cf. with the main standpoints of the 'new economic geography,' that are practically convergent to the above), the scarcity principle is put to the test.

Thus, a maritime cluster seems to portray a scarcity paradox, since within a given region, for no apparent and straightforward cause, an abundance of firms is situated within the direct proximity of an excess of competitors. These maritime firms are active in the same field and theoretically compete within the same markets, for the same resources. But instead of merely competing, they are found to make up a cluster, that guides the prosperity and competitiveness of the whole region. Rather than hostile tactics, these entities make use of constructive competition and synergistic cooperation that formulate a culture which, in terms of resources, resembles the cyclical and perpetual motion of nutrients' flows embedded in nature's paradigm; and this, through the catalysts of knowledge creation and innovation.

Therefore, as per the business context wherein a cluster is active, resources are indeed finite, but at the same time these exact resources can sustain an overabundance of industrial activity; as much as is required for the whole world to notice and as much as is required to generate interest in practice, policy, and academia, to study and possibly recreate the phenomenon. The reason behind this multifaceted interest has hid in obscurity and is none other than the scarcity paradox. The mere existence of the scarcity paradox is what generates and fuels the attention exhibited towards clusters; if it was not for this paradox, any cluster would be a matter of business as usual. As a result, reasoning to investigate the scarcity principle's applicability within a cluster should surface both as relevant and important; an initial resolution of this query would result from modelling the scarcity principle and considering its applicability within an industrial cluster. Herein, the maritime sector has formulated the case in point, where through paradox, a new approach as to the rudiments of clusters is provided.

4 Scarcity paradox modelling

Per scarcity principle designation, resources within a given region are bound by an upper limit and are not endless. At first, one should consider the representation of a 'given region.' This would entail a context that is fixed, with clear boundaries: a given geographical area, defined and bound, either by natural geography, and/or sovereignty. The point to be made is that the region may not be altered, no matter what has created its boundaries. For systems' theory, if the region was to be considered a system, this would be (geographically) isolated. Thus, the regional setting of the model would resemble an isolated system, that does not allow any exchange, at least with respect to its land mass. The next formative component of the model should pertain to the substantiation of the conceptual framework of scarcity, its upper limit, and the finite nature of resources. If one was to utilize a mathematical notation, this instance would be represented by the simple summation found in Equation (1), where 'R' denotes a resource.

$$\sum_{i=1}^{n} R_i = const, n \epsilon \mathbb{N} \quad (1)$$

Per Equation (1), the summation of resources for the isolated system is a constant. One would gather a finite sum of resources, wherein these may be converted over time, but their total sum would have to remain constant. Without a large stretch of speculation, the scarcity principle, within this portrayal, bears attractive semblance to the law of conservation of energy. The law, a fundamental component of modern physics, states that energy within an isolated system (wherein no transfer of matter or energy may take place) remains constant. Energy may not be created, nor destroyed, but rather, transformed. In this system, the sum of energy and mass must remain constant. If one was to represent only the energy aspect of the law, this would be portrayed in a summation, such as the one within Equation (2), where 'E' denotes energy.

$$\sum_{i=1}^{n} E_i = const, n \epsilon \mathbb{N} \quad (2)$$

The identical nature of Equations (1) and (2) is inescapable. At least within a modelling perspective, the scarcity principle seems to behave as an application of the law of conservation of energy, for a geographical system; much as it behaves for a thermodynamic system and is transformed to the first law of thermodynamics. Through this relevant understanding, the scarcity principle is modelled due to its semblance to the law of conservation of energy and maybe, any prospective synergies among the two should be further considered. The finite resources will formulate a common pool wherein any entity within the geographical district may tap, to fulfil its mission. Within the simple application of the conservation of energy, each resource may be utilized and transformed, so long as the summation of resources remains constant. The cases of thereafter utilization, or life cycle termination, would be a matter of the culture within the district. Exactly within this understanding does the relevant interpretation of the scarcity principle with reference to the law of conservation of energy lie.

The value system within the region will dictate if within the process of resource transformation, the latter will be utterly spent, or pertain to resource intake for a subsequent procedure. But this kind of resource pooling and systemic allocation, or rather, this distinct conceptual regard towards resources would give way not only to a unique culture of proximate dynamics (that needn't be considered universal and thus are admired and sought after), but also to a fundamental fracture within the applicability of regional scarcity. That said, if the scarcity principle is an application of the law of conservation of energy for systems of economies, the relevant scarcity paradox within maritime clusters would have to violate a fundamental law of nature. The investigation into the components of the law of conservation of energy sheds light into this dilemma.

The law of conservation of energy can include many forms of energy that may be converted into one another, so long as their sum remains constant. If an object falls within a gravitational field, its gravitational energy is transformed into kinetic energy. If it hits the ground, its kinetic energy is transformed into heat, that is, molecular kinetic energy. All the while, types of energy are converted; no energy is created, nor destroyed. A form of energy that is relative to where an object of study is positioned and may interest scarcity principle modelling, is potential energy. This type of energy was coined by Rankine in the 19th century and has its conceptual basis within Aristotle's theory of potentiality. Within this context, there are two constructs, potentiality and actuality. The former considers the capacity of the materialisation of an event, whereas the latter, entails the fulfilment of this capacity. If the conceptual analogue of energy for economics is a resource, then the notion of the case of potential energy should be recovered. Thus, the equivalent of potential energy within a maritime cluster, or indeed any cluster, would manifest as a potential resource.

In all fairness to the theory, the dynamics within a maritime cluster could provide a conceptual parallel to potentiality, without violating the scarcity principle. One could consider that the resources within a cluster are finite, but that, at the same time, there also exists a mechanism within that uncovers potential resources. This can be conceptually justified by the fact that within a maritime cluster, the culture of mutualism and collectiveness gives birth to a system of innovation that reveals these, otherwise hidden, potential resources. Without loss of generality to the theory of potentiality, one can safely prompt the suggestion that, innovation transforms potentiality into actuality, within a maritime cluster. The potential is situated within the region all along, but a culture of collectiveness, mutualism, and innovation is required so that the resource is positioned into a focal point. One could ponder as to the capacity of this culture in reviving regions whose economies are considered toxic.

Therefore, even with full consideration of the scarcity principle, a cluster can sustain a culture that may nurture innovation, that will act as the catalyst in spelling out and guiding the process of uncovering and utilizing potential resources. In the modelling respect, a distinction should then be provided for this mechanism to bear a different representation, other than the one of conventional resources. This could be embodied with a construct pertaining to the coexistence of resources, both conventional and potential. This accord would include the existence of two sums. The first would contain the generic sum of resources that is in sync with the scarcity principle and equal to a constant, as presented in Equation (1). In addition, a second term must be included, that represents the potential resources, let it have notation 'PR.' For this second term to comply with the principle of scarcity, its sum should be a constant as well. Thus, both sums are equal to a constant, as portrayed within Equation (3).

$$\sum regional\ resources = \sum_{i=1}^{n} R_i + \sum_{j=1}^{m} PR_j = const, n \in \mathbb{N} \quad (3)$$

The conventional resources would then be utilized in tandem with potential resources, but the overall summation would have to remain constant, to conform with the scarcity principle. Of course, even if these sums are both constant, the sequence of factors within is not analogous. Conventional resources may have a finite sum, as well as a finite sequence of terms. But if, on the other hand, within the cluster, the system of innovation uncovers resources in a cyclical manner, then this would mean, that, at least theoretically, the summation of potential resources, could be infinite. Then, the sum of Equation (3) would encapsulate a finite summation and an infinite summation, that when added, should result to a constant. Since the total resources are equal to a constant and the potential resources must remain constant as well, one may render the portrayal in Equation (4), for the summation of potential resources.

$$Total\ potential\ resources \equiv \sum_{j=1}^{\infty} PR_j = const \tag{4}$$

Equation (4) may generate the query as to its manifestation feasibility within a regional economy, as it is a constant summation of infinite factors, though calculus has already side-tracked this dilemma, through the theory of infinite series (that have many applications beyond pure math, in physics, economics, etc). The construct for mathematical analysis, that pertains to an infinite summation that is equal to a constant, is none other than a convergent series. Let $\{a_n\}_{n=1}^{\infty}$ be a sequence within $\mathbb{N}$ = {1, 2, 3, . . .}, or $\mathbb{Z} \geq 0$ = {0, 1, 2, 3, . . .}. This sequence is a function f: $\mathbb{N} \rightarrow \mathbb{Z}$, since its range can be positioned within real numbers. The limit of the sequence is $\lim_{n\to\infty} a_n = L$ if for every $\epsilon > 0$ there is a $N > 0$ so that whenever $n > N$, $|a_n - L| < \epsilon$. If $\lim_{n\to\infty} a_n = L$ exists, the sequence converges. An infinite series is an expression of a sequence $\{a_n\}_{n=1}^{\infty}$, such as the one within Equation (5).

$$\sum_{n=1}^{\infty} a_n = a_1 + a_2 + a_3 + \cdots \tag{5}$$

The sequence $\{a_n\}_{n=1}^{\infty}$ involves an N^{th} partial sum as is included in Equation (6).

$$S_N = \sum_{n=1}^{N} a_n = a_1 + a_2 + a_3 + \cdots + a_N \tag{6}$$

The sum of the series $S = \sum_{n=1}^{\infty} a_n$ is equal to the limit of its partial sums, as in Equation (7).

$$S = \lim_{N\to\infty} S_N = \lim_{N\to\infty} \sum_{n=1}^{\infty} a_n \tag{7}$$

If this sum exists, the series converges. For the scarcity paradox to be modelled effectively, this process is rather reversed. Through the mathematical robustness of the proof sequence, calculus infiltrates the priority of the process to the existence of the sum, whereas for scarcity modelling, the analysis begins with the fact that the sum exists, since it refers to the upper limit of the regional resources. The issue with the scarcity paradox is that the infinite sum of

the resources must be equal to this constant. But as the summation in Equation (4) is equal to a constant, through the theory of infinite series, calculus generates the possibility that there exists an infinite series which converges to this same constant. In this manner, a maritime cluster's potential to uncover resources and accommodate a populous concentration of activity is explained, without violating the scarcity principle. With this justification, the scarcity paradox has been deconstructed. Not only this, but the model demonstrates that the cluster can uncover potential resources in perpetuity and that their infinite summation may be equal to a constant, simultaneously. Through this prism, not only does innovation not breach the scarcity principle, but enforces it, as well. The culture of collectiveness within a cluster can relinquish a system of innovation that taps into an infinite constellation of potential resources. At the same time, innovation may transform potentiality into actuality in perpetuity, in a sum that remains constant; all the while, there may exist an infinite series that converges to the same constant as the sum of potential resources. Through this understanding, the infinite summation of potential resources can be denoted as in Equation (8).

$$S_{PR} = \lim_{N\to\infty} S_N = \lim_{N\to\infty} \sum_{n=1}^{\infty} PR_n = PR_1 + PR_2 + \cdots + PR_n + \cdots = const \quad (8)$$

Consequently, a model for resource allocation within a maritime cluster has been delivered, that explains innovation dynamics in complete accordance with the principle of scarcity. Therefore, with this model, a pillar is set for explaining and modelling innovation and scarcity. Notwithstanding, this first attempt could provide the necessary foundation that may bloom into further ground-breaking empirical investigation. The latter may serve to formulate a framework that can sustain different aspects of the model for diverse case studies, whereas the former can assess the effectiveness of these constituents. For instance, based upon this model and apart from studying its applicability within maritime cluster cases, specific infinite series that converge may be put to the empirical test. One may model exactly how innovation

may present a multiplier effect through the Fibonacci sequence, where the infinite series of reciprocals converges to the reciprocal Fibonacci constant, ψ (=3.359885…); thus, the model will render Equation (9).

$$\sum_{n=1}^{\infty} PR_n = PR_1 + PR_2 + \cdots + PR_n + \cdots = const = \sum_{k=1}^{\infty} \frac{1}{F_k} = \psi \quad (9)$$

What may stand between the Fibonacci sequence and innovation, may bridge the latter with factorials. Through the modelling perspective, this infinite series will converge to Euler's number, e (=2.71828), as in Equation (10).

$$\sum_{n=1}^{\infty} PR_n = PR_1 + PR_2 + \cdots + PR_n + \cdots = const = \sum_{n=0}^{\infty} \frac{1}{n!} = e \quad (10)$$

Alternating harmonic series may as well model resource depletion along with innovation externalities, whilst sourced from the initial modelling aspect formulated herein. The list may not be endless but is surely diverse and abundant. Through the formulation of this model, a novel direction for the empirical investigation of the fundamentals of maritime (and notwithstanding, all types of) clusters is provided.

5 Conclusions

Paradox in cluster theory could be expected to hinder its validity, yet it can be utilized to bridge theories concerning clusters, thus creating synergies (Virta and Lowe 2017); the former can relate to viable strategies that can tackle many relevant conundrums within management science (Beech et al. 2004; Clegg et al. 2002; Ford and Backoff 1988; Lewis 2000; Smith and Lewis 2011; Quinn and Cameron 1988). The scarcity principle dictates that the amount of resources within a given district is not infinite and that the entities within must compete for the sustenance these resources promise. This notion gives way to rational thought and to strategies of prudence. But it does not explain how, within a given region with

no apparent distinction to any other locality, an overabundance of entities with parallel objectives, profiles, and requirements for resources, may thrive simultaneously. Thus, in maritime clusters a kind of scarcity paradox is prevalent. This paradox seems to circumvent scarcity and lead to collective prosperity. Its governing parameters could be theoretically explained with many constructs, such as innovation and culture. Innovation may guide cluster members to tapping into resources that were never acknowledged, whereas culture may provide the necessary societal dynamics that will lead to a practical manifestation of industrial mutualism. Indeed, research shows that maritime cluster members seem to regard each other and their cluster, as kin. Yet, in the modelling respect, the scarcity paradox within maritime clusters has not been investigated.

A principle that provides much semblance to that of scarcity, is the law of conservation of energy. They both portray the fact that within a given system, the amount of available and exploitable potential, either exhibited as energy (for physics), or resources (for economics), is not infinite. If one was to build upon this notion, for the sake of model formulation, she would have to tap into its components. Immediately, one concept that surfaces to provide much interest towards cluster dynamics, is that of potential energy. The equivalent within a cluster would consider a potential resource; one could form the conjecture that the mechanism of cluster culture, along with the system of innovation within, may uncover potential resources that would otherwise remain obscure. This understanding provides a plausible framework to explain the scarcity paradox, but it leaves out the fact that, based on the scarcity principle, the sum of resources is not infinite, but a constant.

At the one hand, a maritime cluster may be able to uncover potential resources in perpetuity and at the same time these resources must sum up to a constant. This behaviour can be portrayed effectively through the formulation of the model relinquished herein. The model contains two aspects, the sum of conventional resources that is finite and the sum of

potential resources that entails an infinite summation. This summation can very well be assumed to encapsulate an infinite series that converges to the same constant, as the sum of potential resources. This understanding, though inclusive of modelling allowances, could provide the basis for the utilization of infinite converging series to model maritime (as well as generic industrial) cluster dynamics. This work provides a baseline for the explanation of a rudimentary paradox for industrial clusters, that may prove to serve as the initiation of many pertinent empirical and theoretical studies, in addition to bearing distinct contributions to management, governance, and policy. As a lateral contribution to the literature, the correlation of the scarcity principle with the law of conservation of energy is documented, as well.

Through this work, the body of knowledge with respect to industrial, and more specifically, to maritime clusters, is enriched. Not only is a rudimentary cluster paradox identified and analysed, but at the same time it is deconstructed through a pertinent calculus instrument. In addition, the latter can prove to have many other applications in scarcity theory. The paradox that lies within fundamental notions that concern clusters is one step towards interpretation, since from the modelling perspective, one can demonstrate that not only can scarcity exist within a cluster perspective, but that it may be modelled effectively, through an infinite converging series. This research can be the starting point of investigating which series can properly model the different typologies of industry clusters and furthermore, if cluster dynamics welcome any other modelling aspect with reference to scarcity. Notwithstanding, by considering the conceptual infrastructure of clusters and providing modelling instruments, the intrinsic benefits and positive externalities of the latter may move one step closer towards replication. Therefore, this work may provide characteristic future potential not only for research, but practice, as well. As the maritime sector resonates with many relevant cluster elements, so can it continue to deliver the groundwork for recreating

the cluster prodigy, that is responsible for so much creative growth and multilateral interest portrayed from academia, business, and policy, alike. The work herein can substantially contribute towards this direction.

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